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Forest Insect And Disease Management

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BIOLOGICAL
EVALUATION R10-82-1

SPRUCE BEETLE

GLACIER BAY
NATIONAL PARK

April 1982

U.S. Department of Agriculture
State and Private Forestry

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INTRODUCTION

The spruce beetle, Dendroctonus rufipennis (Kirby) (Appendix A), is the most destructive pest of mature spruce in Alaska and British Columbia (Werner, et al., 1977; Grant and Cottrell, 1968). Throughout the past decade south-central Alaska has experienced severe bark beetle outbreaks in the Cook Inlet and Kenai Peninsula areas. Over 500,000 acres have been infested since the late 1960's (USDA Forest Service, 1979) and beetle populations still persist in Alaskan white spruce forests (Holsten, 1981).

Bark beetle outbreaks in Sitka spruce are far less common, but do occur periodically following windstorms or other disturbances in the forest. The last major outbreak occurred during the early 1940's, when the spruce beetle killed 35 MMBF[1] of Sitka spruce over 6,400 acres on Kosciusko Island (Hard, 1974). A combination of extensive windthrow, logging, overmature stands, and favorable weather conditions released this outbreak which persisted for five years. In 1956, a smaller outbreak was noted on Dall Island, where 1.5 MMBF of mature Sitka spruce were killed. Since the late 1950's, spruce beetle activity has been limited in Southeast Alaska despite periodic windstorms and logging. Recently, however, small outbreaks have been detected in the drainages of the Whiting and Taku Rivers (Eglitis, 1981) on the mainland of the Southeast Alaska Panhandle between Juneau and Petersburg and near Anchor Point on the southern end of the Kenai Peninsula (USDA Forest Service, 1982).

In the summer of 1981, National Park Service personnel reported extensive mortality of Sitka spruce in Glacier Bay National Park (Figure 1) and requested an examination of the area by Forest Pest Management staff. A preliminary ground check verified that the spruce beetle was associated with the Sitka spruce mortality, and a subsequent biological evaluation was conducted in late August, 1981. The objective of this report is to describe the most extensive spruce beetle infestation currently found in Southeast Alaska.

METHODS

In early August, the southern portion of Glacier Bay National Park was flown in fixed-wing aircraft to delineate the boundaries of the beetle infestation and to select appropriate areas for ground sampling.

Stand composition

Four areas were chosen for variable plot sampling of stand structure and tree mortality (Figure 2). In each area, a 20 BAF prism was used to

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[1] MMBF = million board feet

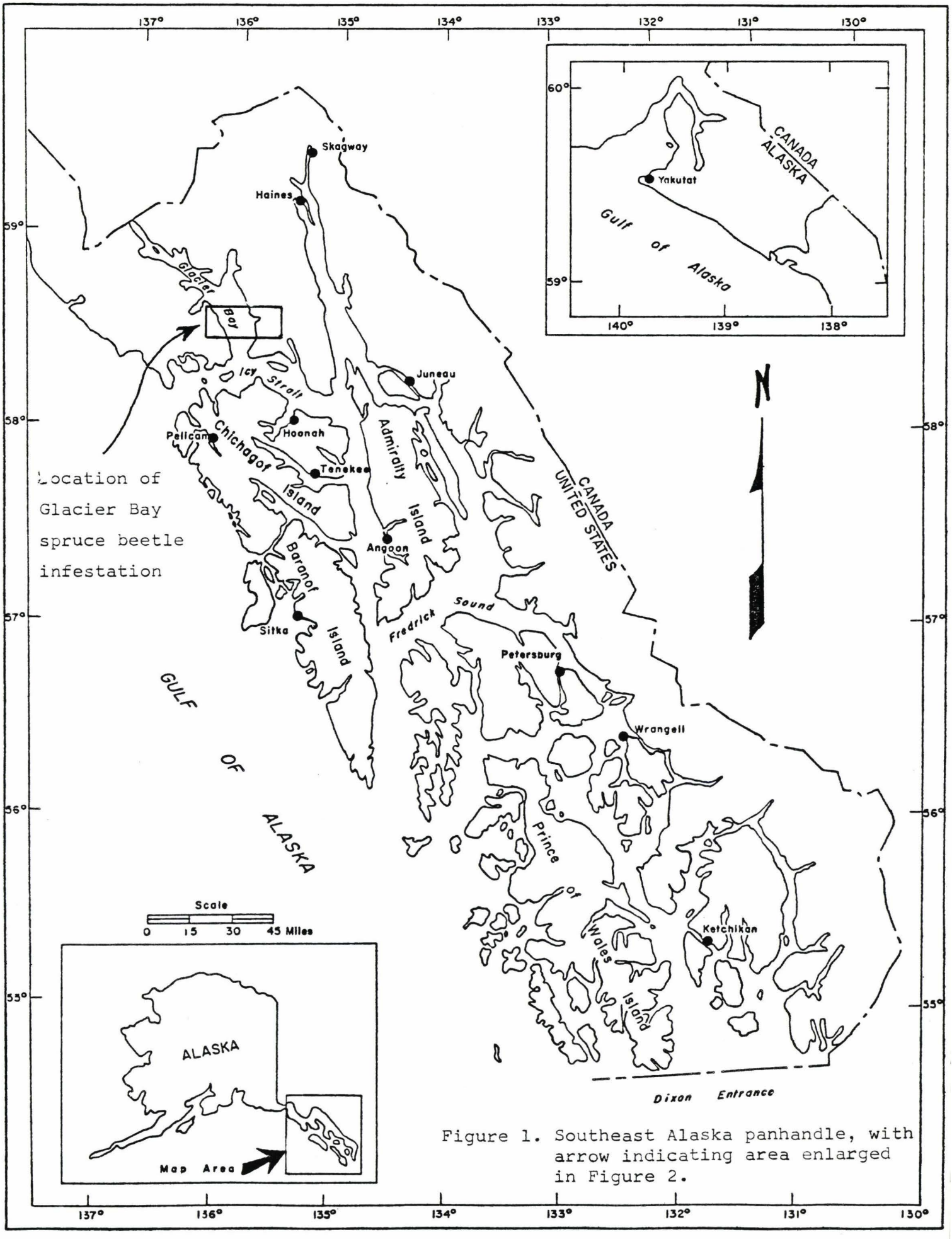
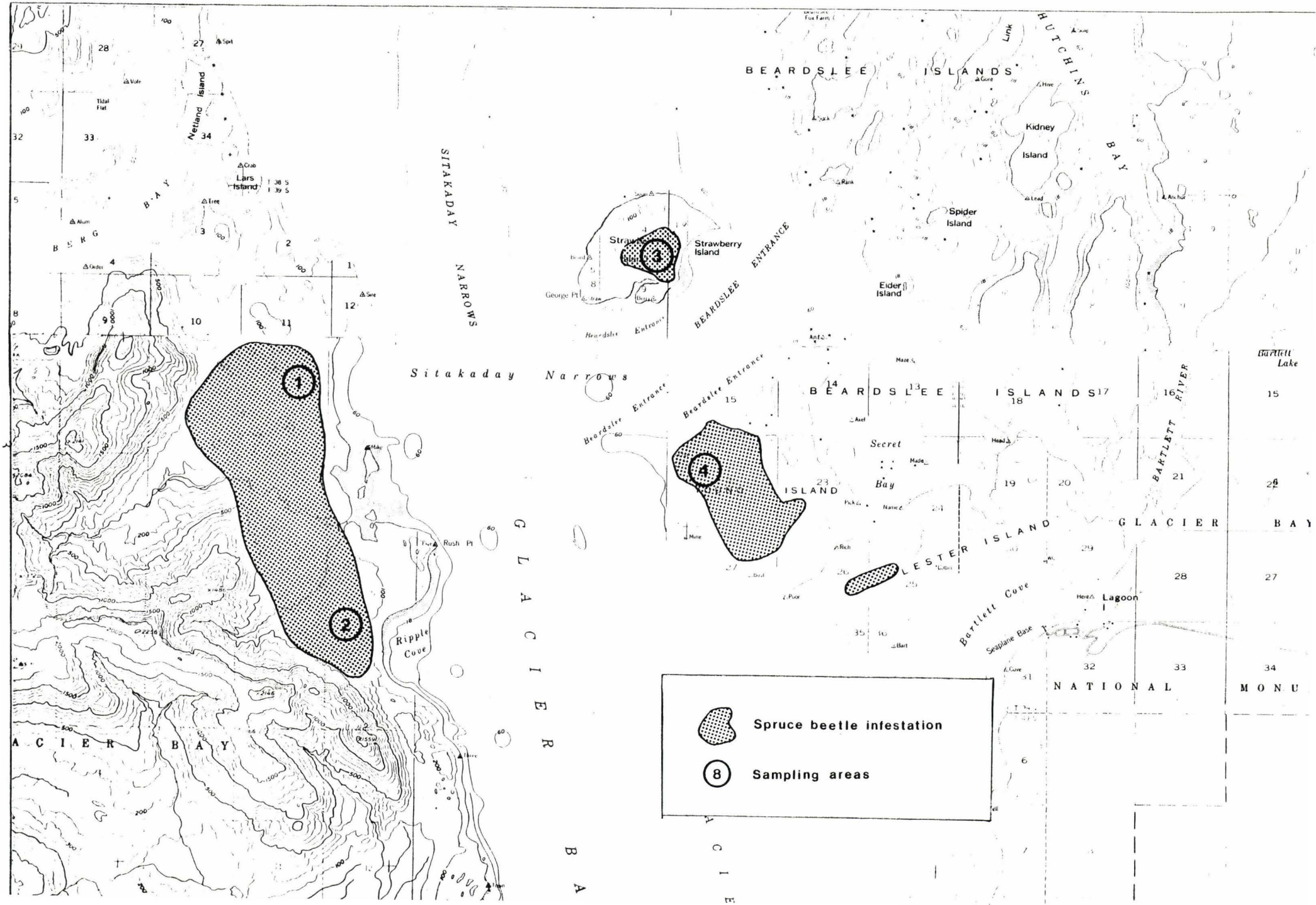


Figure 1. Southeast Alaska panhandle, with arrow indicating area enlarged in Figure 2.

Figure 2. Distribution of the spruce beetle, Dendroctonus rufipennis in standing Sitka spruce in Glacier Bay National Park, Southeast Alaska, 1981. Numbers indicate areas where variable plot sampling was done.


Spruce beetle infestation
8 Sampling areas
1
2
3
4
Sitakaday Narrows
SITAKADAY NARROWS
BEARDSLEE ISLANDS
BEARDSLEE ENTRANCE
Beardslee Entrance
Strawberry Island
Kidney Island
Spider Island
Eider Island
Secret Bay
LESTER ISLAND
GLACIER BAY
Bartlett Cove
Lagoon
Seaplane Base
Ripple Cove
Rush Pt
Lars Island
Netland Island
Tidal Flat
George Pt
Bartlett Lake
BARTLETT RIVER
NATIONAL MONU

establish variable-radius plots at five to six - chain intervals along a compass line. On the mainland west of Bartlett Cove, 10 variable plots were established in each of the two sampling areas designated as Berg Bay (1) and Ripple Cove (2). On the Beardslee Islands, eleven variable plots were established on Young Island (Area 4) and seven on Strawberry Island (Area 3). At each plot, we recorded tree species, diameter at breast height (DBH), tree condition (live or dead), crown condition, and beetle brood present or absent. Tree heights were recorded on one live and one beetle - killed tree per sampling plot, and increment cores were extracted from each of these two trees. Understory vegetation was also described.

Beetle populations

Within areas of active infestation, spruce beetle brood was sampled by removing two 6 X 6" bark samples from opposite sides of each tree at breast height and recording the number of adult spruce beetles per sample. When compared with Knight's (1960) sequential sampling scheme for Engelmann spruce beetle, these numbers aid in predicting population trend.

RESULTS AND DISCUSSION

The location of the Glacier Bay spruce beetle infestation is shown in Figures 1 and 2. The major portion of the infestation lies between Berg Bay and Ripple Cove on the west side of Sitakaday Narrows, where 2,640 acres show extensive spruce mortality. Beetle damage is also evident on the larger southernmost Beardslee Islands. Approximately 800 acres are infested on the western side of Young Island; 170 acres on Strawberry Island; and 60 acres on the west side od Lester Island. The total infested area shown in Figure 2 presently exceeds 3,650 acres (1,660 hectares).

Stand Composition

The lowland forests of Glacier Bay are not typical of the old-growth stands which predominate throughout most of Southeast Alaska. As recently as 1790, most of Glacier Bay was covered with ice. Shortly thereafter, a very rapid glacial recession occurred, leaving extensive morainal and glacial outwash material for plant colonization (Cooper, 1923). The exposed land was quickly invaded by simple plant communities and now relatively even-aged stands of subclimax Sitka spruce (Picea sitchensis (Bong.) Carr.) occupy the low-elevation sites south of Berg Bay and the Beardslee Islands. Although occasional black cottonwood (Populus trichocarpa Torr. and Gray) and western hemlock (Tsuga heterophylla (Raf.) Sarg.) occur, Sitka spruce represents over 90% of the forest vegetation (Table 1).

Table 1

Summary of tree species and diameters recorded on 38 variable plots in four sampling areas throughout lower Glacier Bay National Park. August, 1981.

Sampling Area	Location	Species	Number of trees	Average Diameter
1	Berg Bay	Spruce	107	22.4 +/- 7.5"
		Hemlock	5	14.9 +/- 6.5"
		Cottonwood	7	14.4 +/- 3.0"
2	Ripple Cove	Spruce	125	22.1 +/- 6.4"
		Hemlock	9	13.0 +/- 4.2"
		Cottonwood	2	19.1 +/- 4.2"
3	Strawberry Island	Spruce	91	20.2 +/- 5.7"
		Hemlock	0	
		Cottonwood	0	
4	Young Island	Spruce	121	20.7 +/- 5.7"
		Hemlock	9	14.2 +/- 4.9"
		Cottonwood	2	28.4 +/- 0.9"

Average spruce diameters were 20 inches dbh on the Beardslee Islands and 22 inches on the mainland sites, with less variation than one would find in old-growth forests. The 18 to 28 inch diameter classes accounted for 56% of all spruces examined in the four sampling areas. Basal areas of these spruce-dominated stands ranged from 120 to 360 sq. ft. per acre, and averaged 250 sq. ft. per acre (Appendix B). Tree heights for spruce greater than 20 inches dbh were 119 $\pm$ 13 feet, with the tallest spruce measuring 140 feet. Some of the larger trees in Ripple Cove (Site 2) averaged about 125 years of age.

Understory vegetation in closed stands consisted mostly of mosses and other low-growing herbaceous plants. In several areas, western hemlock seedlings and saplings were evident, particularly on morainal sites. Where stands were slightly more open, the understory vegetation included willows (Salix spp.), alder (Alnus spp.), devil's club (Oplopanax horridus (Sm.) Miq.), and assorted shrub species, sometimes forming nearly impenetrable thickets. Occasional spruce regeneration was also noted in areas where openings had been created in the stand.

Of 444 spruces examined on the variable plots, 203 (or 46%) have been killed by the spruce beetle. Spruce mortality was heaviest in the Berg Bay and Young Island areas (Sites 1 and 4) where 65% of the trees were killed by beetles. In Ripple Cove and on Strawberry Island (Sites 2 and 3) beetles have killed 20% and 30% of the spruce, respectively. Figure 3

shows the beetle-killed and remaining live spruce by diameter class for the combined variable plots in each of the four sampling areas. The average diameters of live and dead spruce are nearly the same in all areas, regardless of the level of infestation (Table 2). It is interesting to note that the beetles did not preferentially attack trees of the largest diameters, contrary to findings in other spruce beetle outbreaks (Baker and Kemperman, 1974; Eglitis, 1981). Consequently, some live large-diameter spruce still remain in each area and the size-class distribution of the stands has not been altered in the same way that we have seen in white spruce outbreaks (Baker and Kemperman 1974; Holsten et. al., 1979).

The level of beetle infestation in Glacier Bay was not correlated with stand density or with individual tree growth. The percent of spruce killed on each sample plot was compared to the basal area for that plot, but results were highly variable. Several plots with low basal areas (less than 200 sq.ft./acre) sustained spruce mortality of 65 to 75 percent, while on some heavily stocked plots (300+ sq.ft./per acre), less than half of the spruce had been killed (Appendix B). Since beetle outbreaks are sometimes related to tree vigor[2], the pre-infestation growth rates of live and dead spruce were compared. Radial growth during the past five years on unattached trees averaged 5.4 mm and on beetle-killed trees, 5.1 mm[3]. These differences in growth rate were not significant at P less than .05.

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[2]John S. Hard, 1982, personal communication

[3]Based on a total of 30 increment cores from dead spruce and 32 cores from live spruce on Young Island, Ripple Cove, and Berg Bay.

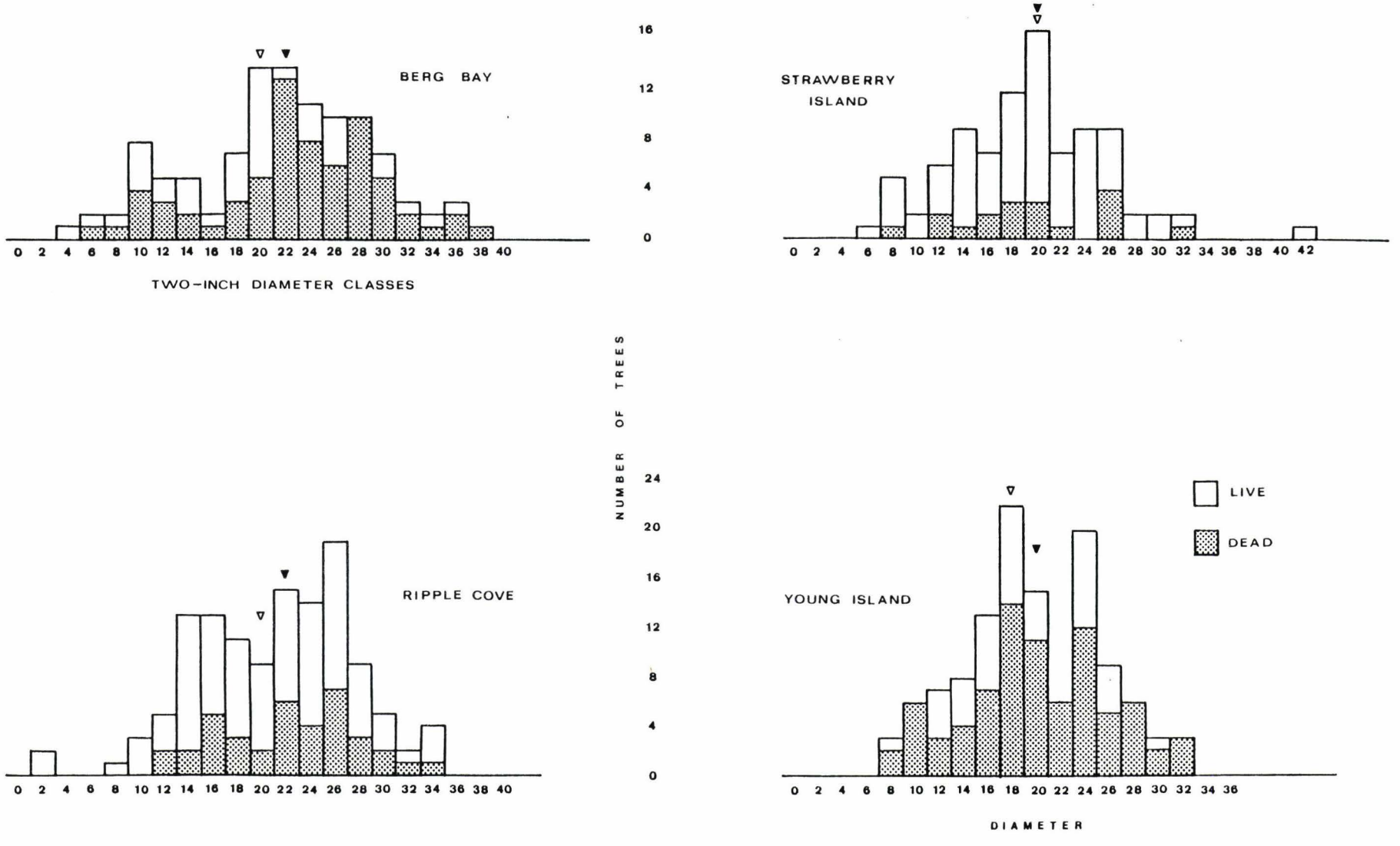

Figure 3. Size class distribution of live and dead Sitka spruce in four sampling areas in Glacier Bay National Park. August, 1981. Arrows indicate mean diameters of live and beetle-killed spruce.

Table 2

Average diameter of beetle-killed and live Sitka spruce in four sampling areas in Glacier Bay National Park. (Trees dead longer than two years are designated as "dead-old"; trees killed in 1980 or 1981 and containing beetle brood are designated as "dead-with beetles").

Area	Category	Trees Number	Diameter	
Berg Bay	Alive	36	21.2 +/- 7.0"	
	Dead-old	45	22.1 +/- 7.2"	
	Dead-beetles	24	25.5 +/- 7.7"	23.2"
Ripple Cove	Alive	85	21.5 +/- 6.8"	
	Dead-old	19	22.9 +/- 5.5"	
	Dead-beetles	19	24.0 +/- 5.9"	23.4"
Strawberry Island	Alive	71	20.0 +/- 6.3"	
	Dead-old	1	8.3"	
	Dead-beetles	16	21.5 +/- 5.5"	20.8"
Young Island	Alive	42	19.8 +/- 5.2"	
	Dead-old	38	22.0 +/- 5.4"	
	Dead-beetles	41	20.3 +/- 6.3"	21.1"

Age of Infestation

The spruce beetle outbreak in Glacier Bay has been in progress since 1978, and possibly earlier. Extensive spruce mortality was evident on color infrared aerial photography taken in August of 1979. At that time, the infestation covered 1750 acres or approximately half the currently affected area. On the mainland between Ripple Cove and Berg Bay, the total infested area covered 780 acres with the most extensive mortality lying due west of the small island bearing the USGS survey marker labeled "Mike". Spruce mortality in that infested area is estimated from the 1979 color infared photography at 30 to 40% of the standing trees. From Ripple Cove northward to the major stream which marked the southern border of the 1979 infestation, spruce mortality was scattered, and appeared very light. The total size of the infested areas on Strawberry and Young Islands has not changed since 1979, although tree mortality has intensified considerably on Young Island in the last two years. Approximately 30-40% of the spruce were dead on Young Island in 1979, and as of 1981, the total has reached 65%. Mortality on Strawberry Island does not appear to have increased since 1979, when 30% of the spruce had been killed. No damage was evident on Lester Island on the 1979 photography.

The oldest beetle-killed trees observed during the ground survey were large spruce bordering a blowdown on the southern end of Strawberry Island. The 40-acre blowdown occurred in 1976[4] and the windthrown spruce may have harbored a beetle population which subsequently killed trees in the surrounding stand. The spruces nearest the blowdown appeared to have been killed in 1977, and possibly earlier. Bark was beginning to slough off these trees, and foliage had been gone for at least three years. Elsewhere, in variable plots on Young Island and in the Berg Bay - Ripple Cove sites, the majority of dead spruce appeared to have been killed recently. In most cases, foliage had fallen from the dead trees in the past two or three years, and no snags were observed where bark had sloughed off.

Describing yearly infestation patterns based on crown and bark condition of beetle-killed trees has proven difficult for Sitka spruce in Southeast Alaska (Eglitis, 1981). Therefore, our basis for aging the infestation consists of grouping dead trees into two categories: those containing first and second year beetle brood and those where beetles are no longer present. This information, together with the 1979 photography, 1981 ground/aerial surveys, and local reports, suggests that over half of the total spruce mortality has taken place in the last two years, and that the outbreak probably began in 1977.

Beetle populations

Although many host trees have been killed, bark beetle populations are still high in Glacier Bay National Park. As shown in Tables 2 and 3, and in Appendix B, over half of the total beetle-killed trees still contain bark beetle broods. The trees attacked in 1980 now contain adult spruce beetles which will fly and attack new trees in the summer of 1982. Other trees, probably attacked in 1981, contain larvae and other immature stages, which will not be ready to fly until the summer of 1983. Another group, representing half of all dead trees with beetles, contained immature stages as well as adults, which could be the result of multiple attacks (i.e., individual trees attacked in both 1980 and 1981, presuming a two-year life cycle) or a differential development rate of a single year's brood (Table 3).

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[4]Gary Vequist, 1981, personal communication

Table 3

Number of trees killed on sampling plots in Glacier Bay and the year of mortality as determined by brood development of bark beetles in dead spruce sampled in August, 1981.

	Year of Attack			
	1981	1981 and/or 1980	1980	pre 1980[4]
	L[5]	LA[6]	A[7]	O[8]
Berg Bay	11	25	9	24
Ripple Cove	3	12	4	19
Strawberry Island	-	1	-	16
Young Island	8	12	18	41
Total	22	50	31	100

[4]"pre-1980" corresponds to trees indicated as "dead old" in Table 2; the other three columns correspond to trees indicated as "dead-with beetles" in Table 2

[5]Trees with larvae present

[6]Trees with larvae and adults present, and occasionally pupae and callows.

[7]trees with adults only

[8]beetle-killed trees where brood adults have left.

The fading and disappearance of spruce crowns appears to be fairly rapid after beetle attack. Half of the dead trees containing larvae, presumably from 1981 attacks, had already lost their crowns by August, and most of the others were sparse and discolored (Table 4). However, the phloem and cambial regions still appeared fresh with little evidence of Armillaria mycelial fans, again suggestive of recent attacks. Most spruces with crowns gone included the long-dead beetle-kills. Virtually all trees with adult beetle brood had no crowns, and most other brood trees had also lost their foliage (Table 4) despite a relatively fresh appearance of the cambial region.

Table 4

Crown color and condition as related to spruce beetle development in beetle-killed trees. Glacier Bay National Park, August 1981.

		BEETLE DEVELOPMENT			
		Larvae	Larvae + Adults	Adults	Beetles Gone
CROWN COLOR	Green	2	8	2	-
	Green/Yellow[9]	2	2	-	-
	Yellow/Brown[9] or Green/Brown	2	3	-	-
	Brown[9]	2	5	2	1
	No Crown	9	33	30	99

Thus, using crown and phloem conditions as indicators, we believe that some of the trees containing both larvae and adult brood could be from single-season (1981) attacks. Other trees with all stages of development may be from a combination of 1980 and 1981 attacks, thereby representing the more common two-year life cycle. At this time, we do not have sufficient information to state how prevalent a one-year life cycle is for the spruce beetle in Glacier Bay, but some of our findings suggest that it does occur.

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[9]In addition to being off-color, these crowns were also sparse in most cases.

Successful colonization of live trees in the form of strip attacks[10] resulted in an additional 28 brood trees throughout three sampling localities: ten trees on plots on Young Island; eight in Berg Bay, and 10 in Ripple Cove (Appendix B).

Bark sampling for adult spruce beetle brood was possible on only 20 trees. In other cases, the beetles had migrated from the infested boles to the tree bases, and could not be sampled at breast height as Knight's (1960) sequential sampling plan requires. The total number of bark samples taken and the number of beetles found in each area are shown in the table below:

Table 5

Number of 6 X 6" bark samples and adult spruce beetle brood in Glacier Bay sampling areas. August 1981.

	# Samples	Beetle Total	Adults per sample
Berg Bay	19	175	9.2
Ripple Cove	8	59	7.4
Young Island	9	59	6.6
	36	293	8.1

According to Knight's sampling plan, an average of two to three beetles per bark sample indicates a static population, and 5+ beetles per sample predicts increasing populations for the next year. Although the total samples taken in Glacier Bay were few, the aggregate of 293 beetles in 36 samples (Table 5) shows that populations are indeed high, and that additional tree mortality can be expected in 1982 for the mainland and Young Island. The infestation appears to have died out on Strawberry Island, as no brood trees were found on or near the variable plots.

Future course of the outbreak

Trends in a bark beetle infestation can be predicted through a variety of indicators which include: 1) average diameters of live and dead trees in a stand, 2) proportion of brood trees compared to trees killed in the previous year, 3) incidence of strip attacks, and 4) adult beetle counts. Since no single indicator is totally reliable, we base our prediction on the composite picture made from considering all of these indicators.

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[10]"strip attacks" denote trees which have been successfully attacked, broods have been established on only one side of the tree, and the tree is still alive.

Dendroctonus beetles generally attack the largest diameter trees available, thereby insuring the greatest rate of brood survival. As an outbreak progresses toward natural collapse, the average diameter of infested hosts declines until unsuitably small trees are being attacked. As shown in Table 2, diameters of the dead spruce which have sustained high beetle populations over the past few years are not significantly larger than the diameters of the remaining live trees in Glacier Bay. Even where the infestation has been intensive, (Berg Bay and Young Island) where 65 percent of the trees have been killed, there are sufficient numbers of large live trees to perpetuate the outbreak.

In all areas except Strawberry Island, the number of trees containing beetles is comparable to the number of old beetle-kills (Tables 2, 3, and 4). Trees shown in Table 3 with "adult beetles only" (presumably killed in 1980) outnumber trees with "larvae only" (killed in 1981), but if a one-year life cycle is prevalent, then some of the trees in the former group might have been killed in 1981. Since we cannot specify a year of attack for the 50 trees containing both larvae and adults (Column 2, Table 3), the ratio of beetle kills in 1981 to 1980 is uncertain, although suggestive of stable beetle populations. Based on this indicator, the infestation is likely to continue for some time in all areas except Strawberry Island, where recent mortality has not occurred.

According to Schmid and Frye (1977), a high incidence of strip attacks is indicative of declining populations. In Glacier Bay, only 28 successfully colonized trees were strip-attacked, as compared to 103 which were killed and currently infested. This number of strip attacks is not of sufficient magnitude to suggest a declining population.

In three of the four sampling areas, adult brood counts exceeded the average of five beetles per sample which indicate increasing populations (Knight, 1960). Although we are uncertain of the applicability of Knight's system to bark beetles in Sitka spruce, this indicator is the best we have for interpreting beetle populations, and would suggest high insect survival rates in the Glacier Bay infestation.

In summary, stand conditions and resident beetle populations are such that additional tree mortality is expected to occur in the Glacier Bay area during 1982. Further intensification of the outbreak is anticipated northward to Berg Bay and southward past Ripple Cove on the mainland, where we have monospecific stands of uniform age. Beetle activity is greatest in the northern extreme of the infested area on the mainland and on parts of Young Island (Appendix B). Stands on Lester Island may also become infested to a greater extent than in the past, due to the proximity of active infestations on Young Island. Two beetle-killed trees have been observed in the immediate vicinity of Glacier Bay Lodge, and additional mortality may occur in this area as well.

Weather factors may be important in how the outbreak develops. Annual precipitation in Glacier Bay has averaged 68" over the last three years, with only 6" of that total coming in May and June when beetle flight and attack occur. Whether early summer moisture stress of Sitka spruce has been a factor in this outbreak is not presently known, but it is often involved in outbreaks of Dendroctonus beetles. The spruce beetle flies and attacks new hosts only after temperatures have reached a critical threshold level in the early summer--usually about 61 F (16 C)(Dyer, 1973). If temperatures remain near this threshold level throughout the season, beetle flights are small and drawn out, and tree mortality is low. However, if temperatures are well above the critical level (61 F) for three or four consecutive days, the majority of beetle flight for the season could occur during this time, and substantial tree mortality would result (McMullen and Atkins, 1962). The maximum daily temperatures in Glacier Bay for May and June, 1978 to 1981 are shown in Appendix C. During those four years, there has been considerable variability in temperature patterns conducive to beetle flight. In 1979, beetle flight in Glacier Bay could not have occurred until mid-June, while in 1981, a large flight probably took place in the first week of May (Appendix C).

Early May termperatures in 1981 were of such a magnitude that virtually all of the beetle flight for the season may have taken place then, resulting in highly successful colonization of host trees through mass attack. Likewise, in 1980, one large and successful flight probably occurred, although it would not have begun until the first week of June. While 1980 and 1981 were good years for beetle flight and attack, 1978 would represent the other extreme. Threshold flight temperatures of 61 F were reached several times during May and early June, which would have led to sporadic beetle emergence and small-scale flights, resulting in less tree mortality. Similarly, the prevailing air temperatures and their distribution throughout May and June of 1982 may have a large influence on the success of this year's beetle population.

The risk of outbreak expansion to areas beyond Glacier Bay is uncertain, but probably not high. Areas near the Bay, such as Excursion Inlet and Pleasant Island, have stands more typical of the rest of Southeast Alaska. Forest types are mixed old growth where western hemlock is the primary stand component, and spruce is less abundant and more diversified in terms of age-class distribution. Traditionally, these stands have been less susceptible than pure spruce stands to bark beetle outbreaks.

SUPPRESSION ALTERNATIVES

Various means of suppression are employed against the spruce beetle, depending on the areas, values, and resource management practices involved. These suppression alternatives will be discussed briefly, since they are treated extensively in the literature (Alexander, 1973; Averill, 1978; Beckwith et. al., 1977; Dyer and Safranyik, 1977; Schmid and Frye, 1977).

Salvage Logging

By this method, currently infested spruce is logged selectively, thereby removing the beetles before they can emerge and attack new hosts. Salvage logging can be quite expensive, but does provide usable lumber. The method has short-term effectiveness since it does nothing to modify the stand conditions which may favor beetle infestation.

Trap Trees

The spruce beetle has a strong preference for down material, and attacks windthrows or logging residuals much more heavily than standing trees. A trap tree may absorb as much as four times the number of beetles as those attacking a standing tree (Dyer and Safranyik, 1979). A commonly used suppression technique has been to fell some trees within an on-going infestation prior to beetle flight, allow them to be attacked, and either remove or treat them after they are infested. Normally, one trap tree is felled for every four or five infested standing trees. The method has more flexibility than salvage logging, but would require two entries into a stand, with timing and tree removal being critical.

Chemicals

Insecticides can be used to prevent successful beetle attacks or to destroy brood in infested trees. Such treatments are costly and time consuming since the boles of individual trees must be treated by ground application. The use of beetle pheromones may have some application in the future, primarily as attack deterrents. The pheromone technique, however, is not yet operational for large areas.

Silvicultural Manipulations

Certain stands are more susceptible than others to bark beetle attack. For some species of spruce, the stand characteristics for susceptibility have been identified, and guidelines for management are available using a risk-rating system (Schmid and Frye, 1976; Holsten and Wolfe, 1979).

The silvicultural manipulations would be designed to reduce risk by reducing basal area, removing individual susceptible trees, and generally improving the overall vigor of the stand. Such "beetle-proofing" techniques are the ideal approach, but they require a commitment to intensive management for the timber resource.

RECOMMENDATION

Given an area where the management emphasis is on recreation and where visitors expect to enjoy an environment altered only by its own forces, we recommend that no suppression activity be undertaken against the spruce beetle outbreak. Since human activity is not implicated in the current

infestation at Glacier Bay National Park, the bark beetle in that area can be viewed as a natural part of the environment. The early-succession spruce stands have reached a stage of high susceptibility to bark beetles, and certain climatic factors have probably aided an outbreak originally triggered by phenomena still unknown to us.

The incidence of spruce mortality in the immediate vicinity of Glacier Bay Lodge is of some concern. These dead trees represent a potential hazard to people residing in the lodge, and to structures as well. These trees (two at this time) should be removed, thereby eliminating a source of beetles as well as insuring that damage from wind breakage does not occur. Other trees near the lodge may be attacked in the future, and all sizeable trees in the lodge area should be inspected for attacks this summer following the beetle flights in June.

Since basic biological information on the spruce beetle in Sitka spruce is minimal, it is recommended that studies of this infestation be encouraged. The factors triggering outbreaks in Sitka spruce must be determined, and reliable indices need to be developed for predicting population changes from year to year.

BIBLIOGRAPHY

Alexander, Robert R. 1973. Partial cutting in old growth spruce-fir. USDA Forest Service Research Paper RM-110, 16 p. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, Colorado.

Averill, R. D. 1978. Spruce beetle -- Summit Lake. Biol. Eval. R-10-78-3. For. Ins. and Dis. Mgmt., State and Private Forestry, USDA Forest Service, Alaska Region. 8 p.

Baker, Bruce H. and Jerry A. Kemperman. 1974. Spruce beetle effects on a white spruce stand in Alaska. J. For. 72(7):423-25.

Beckwith, R. C., J. O. Wolff, and J. C. Zasada. 1977. Bark beetle response to clearcut and shelterwood systems in interior Alaska after whole tree logging. USDA Forest Service Research Note PNW-287, 7 p. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Cooper, William Skinner. 1923. The recent ecological history of Glacier Bay, Alaska. I. The interglacial forests of Glacier Bay. Ecol. 4(2):93-128.

Dyer, E. D. A. 1973. Spruce beetle aggregated by the synthetic pheromone frontalin. Canadian Journal of Forestry Research 3:486-494.

Dyer, E. D. A. and L. Safranyik. 1977. Assessment of pheromone-baited trees on a spruce beetle population (Coleoptera: Scolytidae). Canadian Entomologist 109:77-80.

Eglitis, A. 1981. Spruce beetle: Taku River, Tongass National Forest. USDA Forest Service. Biological Evaluation R10-81-2. State and Private Forestry, Alaska Region. 17 p.

Grant, J., and C. B. Cottrell. 1968. Spruce beetle in British Columbia (Rev.). Forest Insect and Disease Survey. Forest Pest Leaflet 13, 7 p., illus. Forestry Research Laboratory, Victoria, B.C.

Hard, John S. 1974. The Forest Ecosystem of Southeast Alaska. 2. Forest Insects. USDA Forest Service General Technical Report PNW-13. 32 p.

Holsten, Edward H. 1981. Spruce beetle: Chugach National Forest and adjacent lands. USDA Forest Service, Biological Evaluation R10-81-1 State and Private Forestry, Alaska Region. 18 p.

Holsten, E. H. and R. L. Wolfe. 1979. Spruce beetle risk rating system for white spruce on the Kenai Peninsula. State and Private Forestry. USDA Forest Service. Tech. Report R10-1, 21 p.

Holsten, Edward H., Ken Zogas, and Robert Wolfe. 1979. Resurrection Creek spruce beetle infestation: A Three Year Interim Report. USDA Forest Service, Alaska Region. 20 p.

BIBLIOGRAPHY cont.,

Knight, Fred B. 1960. Sequential sampling of Engelmann spruce beetle infestations in standing trees. USDA Forest Service Rocky Mountain Forest and Range Experiment Station Research Note No. 47. 4 p.

McMullen, L. H. and M. D. Atkins. 1962. On the flight and host selection of the Douglas-fir beetle, Dendroctonus pseudotsugae Hopk. (Coleoptera: Scolytidae). Canadian Entomologist 94(12):1309-1325.

Schmid, J. M. and R. H. Frye. 1976. Stand ratings for spruce beetles. USDA Forest Service Research Note RM-309, 4 p. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, Colorado.

------- 1977. Spruce beetle in the Rockies. USDA Forest Service General Technical Report RM-49, 38 p.

USDA Forest Service. 1979. Forest Insect and Disease Conditions in Alaska. Forest Insect and Disease Management, State and Private Forestry, Alaska Region. Series No. R10-31.

USDA Forest Service. 1982. Forest Insect and Disease Conditions in Alaska in 1981. Forest Insect and Disease Management, State and Private Forestry, Alaska Region (in press).

Werner, R. A., B. H. Baker, and P. A. Rush. 1977. The spruce beetle in white spruce forests of Alaska. USDA Forest Service General Technical Report PNW-61. 13 p.

Wygant, N. D. , and R. R. LeJeune. 1967. Engelmann spruce beetle Dendroctonus obesus (Mann) (=D. engelmannii Hopk.) p. 93-95. In: Important forest insects and diseases of mutual concern to Canada, the United States and Mexico. Canadian Department of Forestry and Rural Development, Publication No. 1180, Ottawa, 248 p.

APPENDIX A

Spruce Beetle
Dendroctonus rufipennis (Kirby)
(Coleoptera: Scolytidae)

HOSTS: Engelmann, white, Sitka, black spruce

DISTRIBUTION: Wherever spruce is found; a serious forest pest in southcentral Alaska throughout Cook Inlet and Kenai Peninsula.

DAMAGE: Larvae feed beneath bark, usually killing affected trees.

DESCRIPTION: Adult spruce beetles are dark maroon to black, cylindrical in shape, approximately 5 mm long and 3 mm wide. Larvae are stout, white, legless grubs, 6 mm long when full-grown. The pupae are soft-bodied, white, and have some adult features.

BIOLOGY: The life cycle of the spruce beetle may vary from one to three years, with a two-year cycle being the most common. Temperature plays an important part in determining the length of time required for beetle development.

Adult beetles become active in the spring (late May--early June) when air temperatures reach a threshold of 16 C (61 F). At this time, beetles emerge from trees in which they overwintered, and fly in search of new host material. These dispersal flights may be short-range even though beetles are capable of flying for several miles without stopping.

Spruce beetles prefer to attack the sides and bottom surfaces of windthrows or other down spruce which have been on the ground less than one year. In the absence of such host material, large-diameter live trees may be attacked instead, and if beetle populations are high, these trees may be killed.

Beetle attacks, whether on windthrows or in standing timber, are mediated by pheromones which insure that individual trees will be attacked "en masse", and fully colonized by subsequent broods. Trees that are mass attacked form attractive centers which result in groups of trees being killed by spillover attacks.

Female beetles initiate attacks and begin constructing an egg gallery in the cambium parallel to the grain of the tree. They are joined by males and after mating, lay eggs in small niches along the sides of the egg gallery. Most eggs will hatch by August.

Larvae construct their own galleries in the cambium as they feed perpendicular to the egg gallery. Spruce beetles will pass the first winter in the larval stage, resume feeding the next spring, and pupate by

summer. About two weeks later, pupae transform into adults which will pass the second winter, either in the old pupation site, or more commonly, in the bases of infested trees. The following spring, two years after initial attack, the new adults will emerge and attack new host material.

Virtually all major spruce beetle outbreaks have originated from stand disturbances--blowdown, logging, or right-of-way clearance (Wygant and LeJeune, 1967). Stand susceptibility to beetle attack is described in decreasing order, as follows: 1) large-diameter trees along creek bottoms (highest susceptibility); 2) better stands on benches; 3) poorer stands on ridges and benches; 4) mixture of spruce and other species; and 5) stands of immature trees (lowest susceptibility)(Schmid and Frye, 1977).

APPENDIX B

Stand data from variable plots using 20 BAF prism. Glacier Bay National Park, August, 1981

Area	Plot	Species[1] S/H/C	SPRUCE Live	SPRUCE Dead	SPRUCE Strip[2]	B A[3] ft²/ac	DEAD SPRUCE[4] Old	DEAD SPRUCE[4] New	Beetle[5] Activity
	1	11-0-0	5	6	0	220	1	5	V
B	2	9-0-2	3	6	1	220	0	6	V
E	3	18-0-0	4	14	3	360	3	10	V
R	4	10-0-1	2	8	1	220	2	6	V
G	5	11-0-0	2	9	0	220	1	8	V
	6	7-3-4	4	3	2	280	2	1	M
B	7	7-2-0	3	4	1	180	0	3	V
A	8	9-0-0	4	5	0	180	2	3	M
Y	9	16-0-0	6	10	0	320	9	1	I
	10	9-0-0	3	6	0	180	4	2	I
R	1	10-3-0	5	5	1	260	0	5	V
I	2	11-1-0	10	1	1	240	0	1	M
P	3	15-1-0	12	3	1	320	1	1	M
P	4	14-0-0	9	5	2	280	2	3	V
L	5	14-0-1	10	4	0	300	4	0	I
E	6	14-2-0	6	8	1	320	5	3	M
	7	12-0-0	10	2	2	240	0	2	M
C	8	11-2-1	7	4	1	280	1	2	M
V	9	13-0-0	8	5	0	260	5	0	I
	10	11-0-0	8	3	1	220	1	2	M
	1	13-0-0	1	12	1	260	3	9	V
Y	2	12-3-0	7	5	2	300	4	1	I
O	3	10-0-0	3	7	1	200	7	0	I
U	4	11-5-0	2	9	1	320	4	5	V
N	5	10-0-0	3	7	1	200	5	2	M
G	6	15-0-0	10	5	0	300	5	0	I
	7	11-0-0	4	7	0	220	5	2	M
I	8	9-0-0	5	4	2	180	2	2	M
S	9	7-1-0	1	6	0	160	4	2	M
L	10	16-0-1	4	12	1	340	1	11	V
	11	7-0-1	2	5	1	160	1	4	V
	1	18-0-0	8	10	0	360	9	0	I
S	2	18-0-0	14	4	0	360	1	1	M
T	3	11-0-0	9	2	0	220	2	0	I
R	4	9-0-0	8	1	0	180	1	0	I
A	5	12-0-0	12	0	0	240	0	0	I
W	6	17-0-0	17	0	0	340	0	0	I
	7	6-0-0	3	3	0	120	3	0	I
	38	444-23-11	234	210	28	$\bar{x}$= 250	100	103	

[1] spruce/hemlock/cottonwood

[2] applies to live trees only

[3] basal area

[4] ratio of recently killed to long-dead trees is used as a measure of beetle activity. "New" indicates trees with beetle broods

[5] V=very active; M=moderate beetle activity; I=inactive

APPENDIX C

Maximum daily air temperatures in Glacier Bay, Alaska and spruce beetle flight periods from 1978 to 1981 as indicated by bars.

Date	1978	1979	1980	1981
May 4	46	51	56	56
5	50	56	55	67
6	52	59	56	67
7	49	55	55	66
8	51	56	52	65
9	52	53	58	56
10	56	48	56	54
11	58	49	56	54
12	61	49	60	56
13	56	49	59	55
14	63	55	51	56
15	--	60	57	55
16	53	60	55	54
17	--	49	55	52
18	52	50	54	59
19	50	52	53	59
20	54	54	55	59
21	62	55	54	57
22	64	58	55	60
23	61	53	57	54
24	54	53	60	56
25	51	50	59	58
26	55	52	59	56
27	54	53	63	57
28	51	55	59	62
29	--	53	53	64
30	--	52	55	61
31	46	53	55	57
June 1	57	51	55	50
2	59	52	67	55
3	63	52	66	55
4	59	52	67	52
5	61	56	74	56
6	69	--	74	55
7	68	56	72	57
8	56	51	67	58
9	61	53	60	61
10	64	58	60	67
11	65	58	59	69
12	68	60	55	68
13	64	62	53	66
14		60		
15		66		
16		64		
17		62		
18		57		